Exponent
Failure Analysis Associates®

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August 30, 2020

VIA EMAIL: [redacted]@cwn-law.com

Mr. Kim Estes
COLLIER WALSH NAKAZA LLP
One World Trade Center, Suite 1860
Long Beach, CA 90831

Subject: Fuel High Pressure Pipe Testing
Exponent Project No. 2104797.000

Dear Mr. Estes:

Per your request, this letter summarizes Exponent's testing of the high pressure pipes in the above-referenced matter.

Background

Two fuel lines, No. 5 and No. 6, were removed from the 12K98MC-C diesel engine of the President Eisenhower container ship following the fire incident that occurred on April 28th, 2021. According to specifications provided to Exponent, the rated pressure for the subject fuel lines is 800 kg-f/cm^2 (785 bar, 11,380 psi). However, maximum operating pressure is 387 kg-f/cm^2 (380 bar, 5,510 psi). Exponent was given custody of the two high pressure fuel lines and asked to perform pressure testing of the lines up to 5800 psi (400 bar) to verify that the coupling fittings at the end of both lines, and the inner fuel line protected inside the braided pipe did not have a leak. The test was performed on August 20th, 2021 at the Exponent Los Angeles facility with Mr. David Creager and Mr. John Davis of the United States Coast Guard attending the testing event as well as Mr. Kim Estes present via video conference.

Preparation for Testing

Custom fittings were designed and made to connect the male and female-end connectors at both ends of the fuel lines to the appropriate fluid conductors and pumps. Exponent communicated with engine manufacturer, MAN Energy Solutions – USA (Benjamin Young, manager Technical Field Service), and obtained schematics of the engine fittings. Using these schematics Exponent designed custom fittings and contracted with a third-party machine shop to produce the parts.

Test Setup

The goal of the test setup is to accommodate both low pressure (20 psi) and high pressure (5800 psi) testing without having to modify the system beyond opening or closing a valve. The setup, shown in Figure 2 and Figure 3, also accommodates both simultaneous or independent testing of fuel lines No. 5 and 6 through the use of valves identified in Figure 4. Low pressure is supplied by an electric pump with an in-line regulator set to an output pressure of 20 psi. High pressure is supplied separately by a hand pump capable of up to 40,000 psi. With the lines as-received the custom fittings were torqued onto the male and female-end connectors per specifications supplied by the engine manufacturer. These fittings were then connected to the remainder of the test system as shown in Figure 3.

Low Pressure Testing

The goal of the low-pressure test of 20 psi was to ensure there was no leak in the fitting-connections of the test setup and no through-cracks in the fuel-line pipes, that would not visibly be apparent due to the outer braided pipe. With valves 1 through 6 open the low pressure pump was turned on and hydraulic fluid pumped through the subject fuel lines. The pump was run for approximately one minute to clear air trapped in the test system and subject lines. Subsequently the valves 1, 2 and 3 were closed to achieve a 20 psi pressurization of the subject fuel lines. During this low-pressure test of 20 psi neither of the subject fuel lines leaked.

High Pressure Testing

The goal of the high-pressure test of 5800 psi was to ensure there were no small leaks in the fuel line pipes (that would not have been as evident during low-pressure testing) and to confirm that the male and female connectors of the evidence fuel lines were able to provide the necessary seal to the fuel pump and injector system respectively. During the high pressure testing a hydraulic hand pump was used to pressurize the two fuel lines simultaneously at increments of approximately 140, 1400, and 5800 psi. With valves 1, 2, 3 and 6 closed, the pressure in the two fuel lines was increased by actuating the high pressure pump until each pressure level was reached. Then the system was untouched for a 10 minute observation period and the pressure recorded as a function of time. For the 1400 and 5800 psi pressurizations the system was first allowed to relax (e.g., hydraulic hoses allowed to expand as indicated by a slow pressure drop) and the high-pressure pump was actuated again to increase the pressure back up to the desired value prior to starting the 10 minute observation period. Both of the subject lines were able to maintain pressure up to and including 5800 psi.

Limitations

At the request of Collier Walsh Nakaza LLP, Exponent performed pressure testing on fuel lines. The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the

time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings presented herein are made to a reasonable degree of scientific certainty. We have made every effort to accurately and completely investigate all areas of concern identified during our investigation. If new data becomes available or there are perceived omissions or misstatements in this report, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them.

Please call me at 3[redacted] or email at [redacted]@exponent.com if you have questions or need additional information.

Sincerely,

[redacted]

Alex Zelhofer, Ph.D., P.E.
Managing Engineer

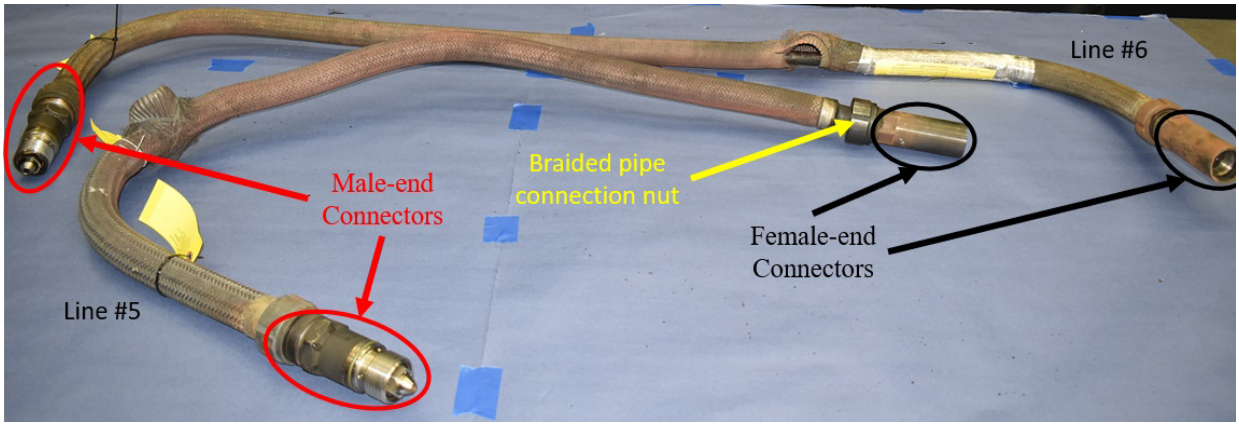

Figure 1. Fuel lines No. 5 and No. 6, as received.

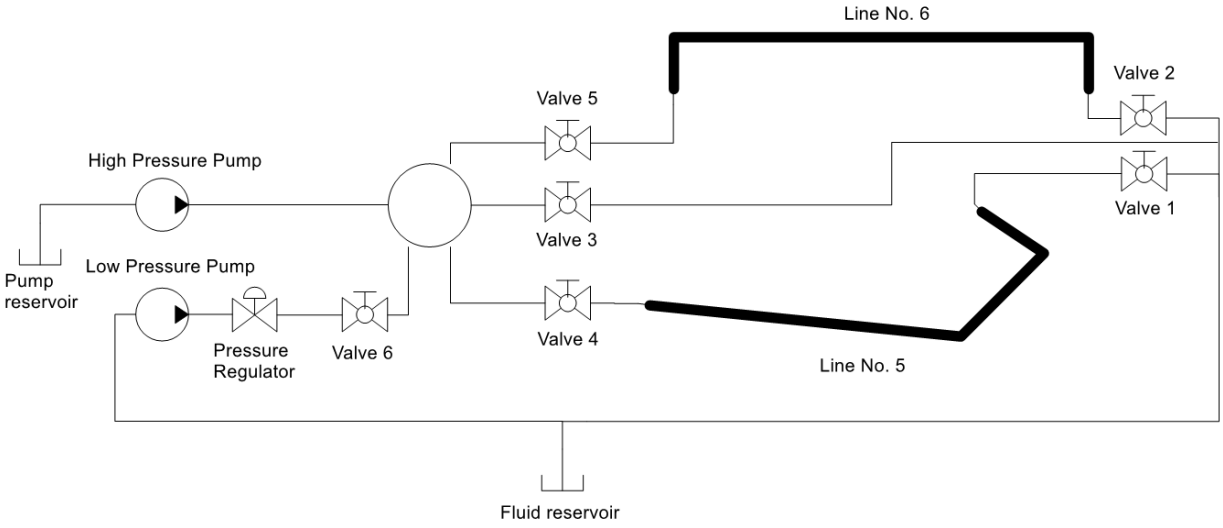

Figure 2. Test setup schematic for both low (20 psi) and high pressure (5800 psi) testing. Bolded black lines indicate the evidence fuel lines No. 5 and 6.

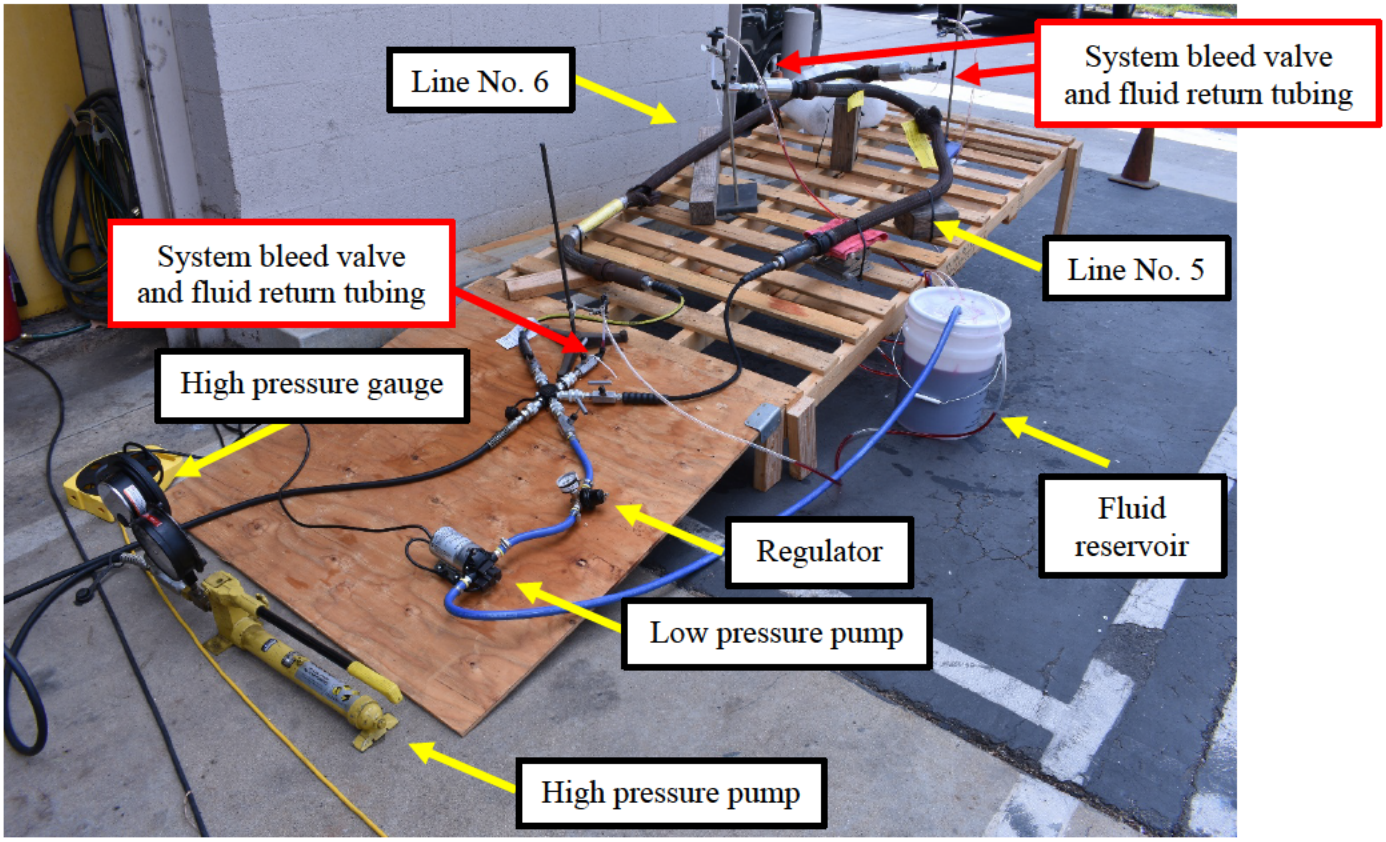

Figure 3. Test setup for both low (20 psi) and high pressure (5800 psi) testing.

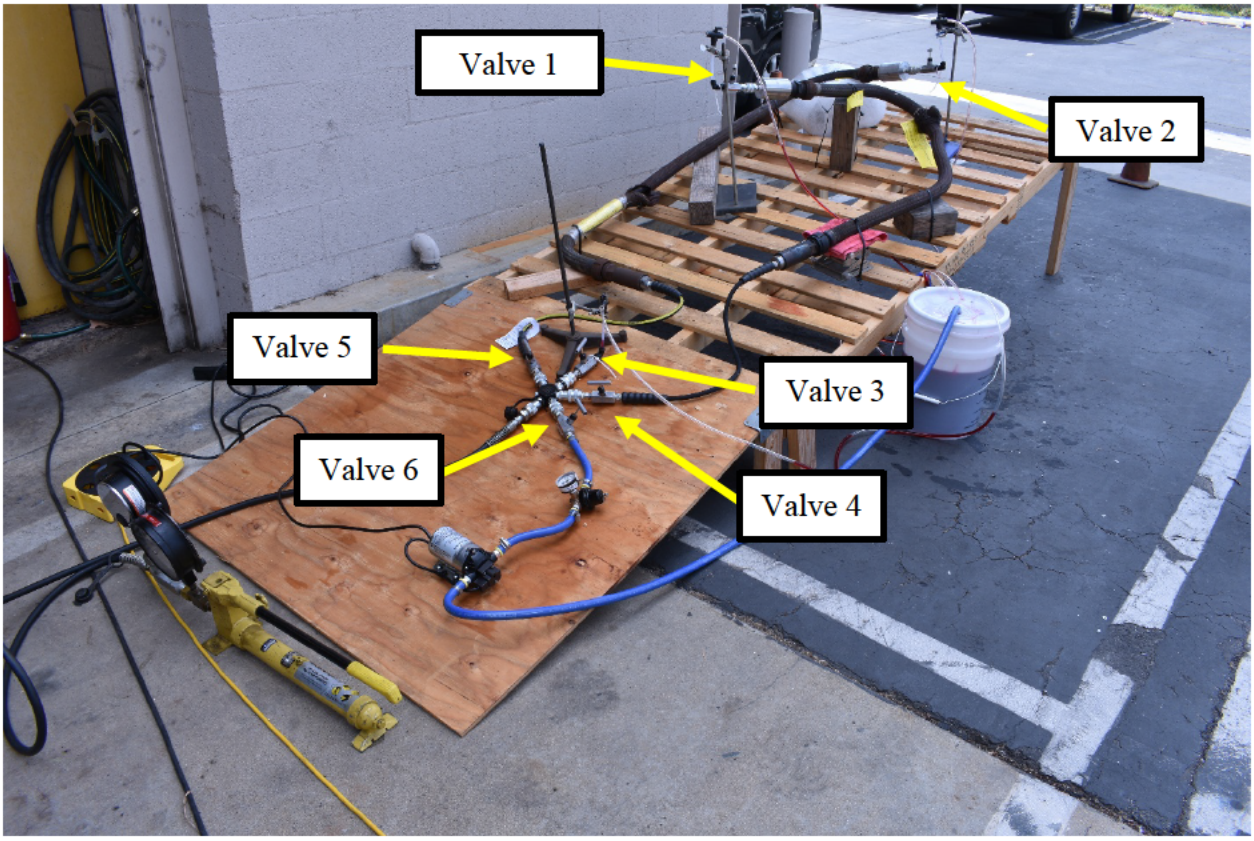

Figure 4. Test setup with labeled valves.